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(71) Applicant *(for all designated States except US):* TARN PURE LIMITED [GB/GB]; Richardson Street, High Wycombe, Buckinghamshire HP11 2SB (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : HAYES, John [GB/GB]; Whitegates, Southlea Road, Datchet, Berkshire SL3 9B7 (GB).

(74) Agent: CRAWFORD, A., B.; A.A. Thornton & Co., Northumberland House, 303/6 High Holborn, London WC1V 7LE (GB).

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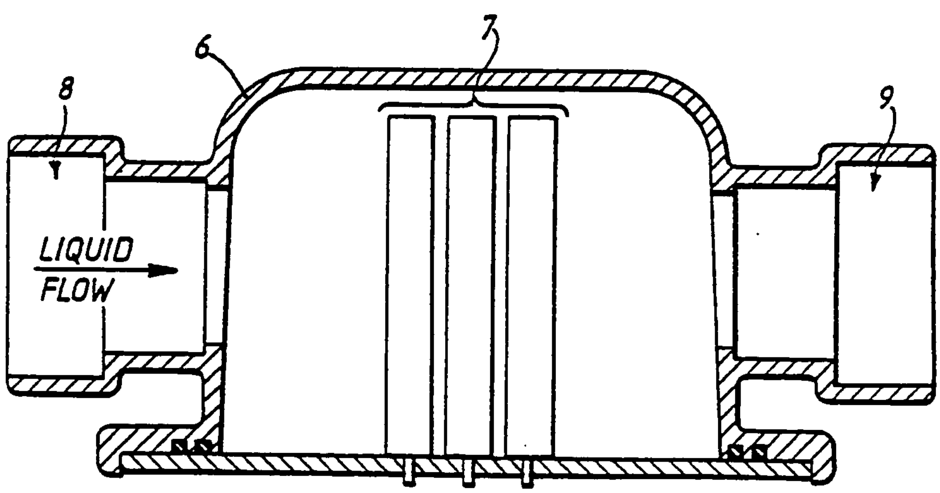
(54) Title: PURIFICATION OF LIQUID AEROSOLS



(57) Abstract

Liquid/gas interface apparatus having means for maintaining the liquid aerosol produced therefrom in a pure form, and to a method of maintaining a liquid aerosol in pure form. It is known that some metal ions, such as copper and silver, have biocidal properties and can be used to purify "standing" liquids. Normal methods of purification are not effective in purifying liquid aerosols. In the present invention metal ions are injected into a liquid prior to the liquid reaching the liquid/gas interface. Liquid aerosol produced at the interface is thus maintained in a pure state. Preferably the ions are injected by a process of electrolysis, utilising a "cluster" of metal electrodes (7) which are placed in the liquid path and are electrically connected in separate sets such that even wear of the electrodes (7) is promoted. The invention is suitable for such for such applications as maintaining the purity of aerosols produced from the "cooling towers" of electricity generating power stations, and aerosols produced by humidifier units in hospital and domestic environments.

Purification of Liquid Aerosols

The present invention relates to the purification of liquid aerosols, and, more particularly, to the purification of liquid aerosols produced by liquid/gas interfaces in, for example, industrial processes, cooling towers and air conditioning apparatus.

A number of situations occur which give rise to the production of a liquid/gas interface. In cooling towers, such as for example, the cooling towers utilised in the electricity generating industry, or those type used in large air conditioning systems.The liquid which is desired to be cooled is mixed with a cool gas in order to evaporate some of the liquid. The loss of the latent heat of vaporisation causes cooling of the remaining liquid.

In air conditioning systems warm water or steam is often mixed with the air to increase the humidity thereof (particularly in cold weather).

Other situations occur, especially within industry, where liquid/gas interfaces are produced.

These liquid/gas interfaces give rise to the production of a liquid aerosol - liquid droplets (eg water vapour) are formed which are carried away by the gas from the liquid/gas interface. For example, some liquid is carried from a cooling tower into the surrounding local environment as liquid aerosol in the air. In an air conditioning unit the water from the humidifier is dispersed in the local environment in order to maintain the optimum water content thereof.

The dispersal of liquids into the environment in this way can be a health hazard. It is known that in, for example, the conduits of air conditioning systems there can be found Legionella Bacteria (which causes Legionnaire's Disease in humans). These bacteria, and other dangerous bacteria such as, for example, Pseudomonas Aeruginosa and E.Coli, may be picked up from

the walls of the conduits and carried into the local environment by water droplets in the water aerosol. In cooling towers, also, harmful bacteria viruses and algea may be picked up off the walls of the cooling tower by the water in the cooling tower and carried into the surrounding environment by water droplets in the aerosol.

The production of liquid aerosols, which are afterwards spread into the environment, can thus result in a considerable hazard to health.

It would therefore be desirable to be able to purify such liquid aerosols in order to ensure that they do not carry such undesirable and harmful bodies (or, at least, if they do carry bacteria, algae and viruses, these are all dead).

It is commonly known to treat standing water (eg swimming pool water), by dosing with chlorine in order to kill off the microbes in the water. This method is effective to some extent as regards the liquid mass itself, although it should be noted that chlorine is only effective if the concentration thereof in the liquid can be maintained at the required effective concentration. If the concentration of chlorine in the liquid drops below the effective concentration algae and bacteria picked up subsequently may remain unharmed in the liquid - note that bacteria such as Legionella can "hide" in algae. Also chlorine tends to have unpleasant and irritating side effects on humans. However, although chlorine may be at least partially effective in purifying a standing liquid mass it is ineffective as regards purification of liquid aerosols.

Chlorine tends to dissociate out of a liquid, particularly when the liquid is mixed with a gas in a liquid/gas interface. For example, in a cooling tower the liquid may be cooled by spraying the warm liquid in a fountain so that it mixes with the cooler air, or by causing the liquid to drip over a series of stacked slats. As the liquid is mixed with the gas in such situations any

chlorine will tend to dissociate out of the liquid such that the chlorine in the liquid as a whole will drop below its effective concentration, leaving the liquid free to pick up any microbes and become contaminated (eg microbes may be picked up by the liquid from the walls of a cooling tower). Any microbes picked up in this way, after the chlorine has dissociated out of the liquid, will remain unharmed. The microbes which are picked up in this way by the "unpurified" liquid may then be carried into the local environment in the liquid droplets of liquid aerosol,constituting a risk to health in the environment.

Thus chlorine, would be ineffective in purifying the water aerosol produced in such liquid/gas interface systems as are employed in eg cooling towers and air conditioning apparatus.

It has previously been proposed to purify standing water (by which is meant water used in applications such as, for example, swimming pools and spas) by dosing the water with certain metal ions (oligodynamic purification) at some point in the water circulation/cleaning system. The metal ions are effective in killing microbes, including algae, in the water without the disadvantage of causing harmful side effects to humans. The application of metal ions in such circumstances is discussed comprehensively in our International Patent Application, publication number WO85/00034.

We have found that metal ions having biocidal properties are effective in purifying and maintaining the purity of a liquid aerosol, because they do not dissociate out of the liquid on creation of a liquid/gas interface.

The present invention provides apparatus for purifying a liquid aerosol, comprising interface means for producing a liquid/gas interface, said means being arranged to have liquid input thereto. and purifying means arranged to receive the liquid input to said interface means and to dose the liquid with metal ions having biocidal properties, whereby liquid aerosol produced from the liquid/gas interface is maintained in a purified state.

The liquid is preferably dosed with silver and copper ions. These have bactericidal and algeacidal properties.

Preferably, the liquid is dosed with metal ions by a process of electrolysis utilising electrodes of the desired metal.

The electrodes utilised are preferably made of silver and copper alloy in suitable proportions.

The circuit parameters used (voltage and current supplied to the electrodes) in the electrolysis will depend on the type of liquid to be dosed and its conductivity,

and tendency to contain microbes. For any given set of conditions it is generally important that the electrode current is maintained at a constant level so that a constant number of ions are injected into the liquid. The current may be increased or decreased if it is required to vary the number of ions going into the liquid.

An External control unit is preferably provided in order that electrolysis conditions may be carefully controlled.

When injecting ions into a liquid by a process of electrolysis it is important that the electrolysis works efficiently so that a controlled amount of ions can be injected. Important factors in ensuring efficiency are even wear of the electrodes, that the electrodes are evenly swept by the liquid, the current being supplied to the electrodes, and whether or not there are any deposits on the electrodes which may effect the ion injection.

We have found that optimum dosing of the liquid with ions can be carried out by utilising an arrangement of a number of electrodes which are arranged together in a "cluster". By "cluster" we mean a number of electrodes which are grouped relatively closely together with regard to the chamber or area within which electrolysis is taking place.

In a preferred arrangement, a number of electrodes are utilised which are grouped together in a cluster. Preferably, the electrodes in a cluster are divided into two separate sets, the electrodes in each respective set being electrically connected together. Electrolytic current flow is between the two sets of electrodes in the cluster, causing deposition of metal ions in the liquid.

Preferably, the electrodes in the cluster are connected together in such a way that the maximum adjacent surface areas of each single electrode are utilised in electrolysis current flow. This has the advantage that electrode wear occurs as evenly as possible, no holes or pits being formed in the electrode surface, so that the concentration of ions entering the liquid can be maintained at a well controlled rate.

In the electrolysis the current direction between the electrodes (or sets of electrodes when they are grouped in a cluster) is preferably reversed periodically.

Current reversal minimises certain adverse electrolytic effects, such as selective deposition on one electrode (or set of electrodes), premature exhaustion of the anode (by virtue of passage of metal ions into solution) and similar asymmetric effects which would lead to the need to replace electrodes more frequently. Current reversal means that the electrodes are effectively self-cleaning.

The electrolysis is preferably carried out in a flow chamber or housing.

The present invention further provides a method of maintaining purity of a liquid aerosol produced from a liquid/gas interface, comprising the step of injecting metal ions into the liquid prior to the liquid reaching the liquid/gas interface, said metal ions having biocidal properties.

The present invention yet further provides electrolytic apparatus for injecting metal ions having biocidal properties into a liquid, the apparatus comprising an electrode chamber having an inlet and an outlet for flow of liquid through the chamber, the chamber housing a plurality of electrodes in a "cluster" formation.

The present invention has the advantage that aerosols produced in eg air conditioning systems in hospitals, cooling towers, and industrial processing can be maintained in a pure state, limiting the dangers of infection and disease from the liquid aerosol.

Copper ions are known to have effective algaecidal properties, and silver ions are highly effective in killing bacteria.

Features and advantages of the present invention will become apparent from the following description of an embodiment thereof with reference to the accompanying drawings, in which,

Figure 1 shows a diagrammatic view of a generalised air-conditioning system employing a process and apparatus in accordance with the present invention;

Figure 2 shows a schematic cross-sectional diagram of a cooling tower employing a process and apparatus in accordance with the present invention;

Figure 3 shows a cross-sectional side view of electrolytic apparatus in accordance with an embodiment of the present invention;

Figure 4 shows a cross-sectional plan view of the apparatus of Figure 3;

Figure 5 shows a schematic plan view of an electrode cluster utilised in an embodiment of the present invention, illustrating how the individual electrodes are electrically connected together, and

Figure 6 shows an electrical circuit which may be utilised with the present invention.

With reference, firstly, to Figure 1, a generalised system for air conditioning a room or area 20 is illustrated.

Conduits 21 take air from the room 20 via low level extract ducts 22, into a recirculation duct 23, to conduit 21a. Conduit 21a contains a number of devices

which can be used in a known way to vary the temperature, humidity and content of air passing therethrough, so that air finally re-entering the room or area 20 via conduits 21b and inlets 24 is conditioned as desired. A smoke extractor outlet 25 and duct 26 is also illustrated.

The conduit 21a houses an air inlet 27, which allows air to be taken from outside the building. A heater 28 heats the air if required. A viscous filter 29 and secondary filter 30 clean the air. A fan 31 promotes circulation of the air through the conduits. Cooling coils 32, connected to refrigerating apparatus comprising refrigerant compressor 33, condensor cooler 34, water pump 35 and expansion valve 36, cool the air if required. A further main heater 37 is provided to heat the air if required.

Reference numeral 39 denotes an air washer which is utilised to regulate the temperature and water content of the air. The air washer 39 operates by spraying an atomised jet of water or steam into the air flow, from a water supply and pump (not shown).

In summer, when the air may already be warm and have high water content, cold water can be sprayed from the air washer 39 which will have the effect of cooling the air and lowering its water content (the lower the temperature of air, generally the less water it holds). In winter, when the air may be cold and have high water content, warm water or steam can be ejected from the air washer 39, which will have the effect of raising the temperature of the air and increasing its water content.

The air washer 39 operates by creating a liquid/gas (water/air) interface, and as a result a water aerosol may be produced when the device is used. As

mentioned above, conduits in air conditioning systems are known to house microbes, some of them quite harmful, which may be picked up by the liquid and carried into the room or area 20 by any liquid aerosol. Particular problems with Legionnaire's bacteria have occurred over recent years in some United Kingdom hospitals (note also that some air conditioning systems utilise cooling towers - some hospital systems have these).

To obviate this problem, in the embodiment of the present invention illustrated in Figure 1 metal ions are injected into the water supply to the air washer 39 by electrolytic device 40. The ions injected are preferably copper and silver, which have known biocidal properties. Any liquid aerosol produced will remain pure because of the presence of copper and silver ions. Any microbes which may be picked up will be killed by the presence of the copper and silver ions.

A control unit 41 is provided external to the sytem, from which current flow to the electrodes in the electrolytic device 40 can be monitored and controlled.

Other water/air interfaces can be used in air-conditioning systems other than the air washer 39. For example, it is known to humidify air be evaporating water heated in open pans, or by dripping water over a series of slots in the path of the air flow. Such interfaces could constitute a health hazard without the use of the present invention.

With reference now to Figure 2 a second embodiment of the invention is illustrated as applied to a cooling tower of an electricity generating station. Like reference numerals denote similar apparatus as in Figure 1.

Evaporative water cooling equipment, such as cooling towers, for example, are used to cool water which has been heated in the process of the generation of electricity in electrical power stations. reference numeral 35 indicates a natural draught hyperbolic-type cooling tower. The tower 45 is arranged such that air

is drawn in through the gap 47 at the base of the cooling tower 45, and upwards through the tower 45, exiting at the top. A "pack" 4b is arranged in the cooling tower to provide a site for a liquid/gas interface. The pack 4b may comprise a series of stacked slats over which the water to be cooled is dripped downwards and mixes with the upwardly flowing air, causing cooling of the water. The water to be cooled is input at the sides of the cooling tower as illustrated by arrows 48 by sprays, so that it may drip through the stack 46. Upcoming air cools the water by a process of evaporation of some of the water, and the cooled water may be taken out from underneath the cooling tower 45.

The liquid in the cooling tower may pick up microbes from the walls of the cooling tower. Any liquid aerosol formed may dispense these microbes into the surrounding environment. This constitutes a health risk to people and animals living in the vicinity of cooling towers.

To obviate this problem, metal ions are injected into the water in accordance with the present invention, prior to the water entering the cooling tower 45,by electrolytic apparatus 40, controlled from an external control unit 41.

An embodiment of electrolytic apparatus 40 utilised in accordance with the present invention will now be described in detail with reference to Figures 3 and 4. A housing 6 is shown which forms a chamber within which is mounted a cluster of electrodes 7. The electrodes 7 are of a suitable metal to produce by electrolysis purifying metal ions with which to dose the liquid. Liquid is passed through the chamber and past the electrodes 7 via openings 8 and 9 in the housing.

The electrodes 7 are generally parallelopipedal in shape. In operation the liquid flows past the electrodes and ions are injected into the liquid as it flows past, by a process of electrolysis. The number of ions injected can be carefully controlled by the associated electrical circuit and control unit 41 in order that a given constant concentration of ions in the liquid may be maintained. An example of an electrical circuit which may be used to control electrolysis is shown in Figure 6. The output terminals are connected to the electrode sets.

The electrodes are electrically connected in separate sets such that electrolysis occurs between the separate sets in order to dose the liquid with metal ions. The electrodes in each set are connected together in such a manner that as much surface area of the electrodes as possible are utilised in current flow. Figure 5 shows an illustration of the electrodes schematically illustrating the connections between the electrodes, the connections being shown by the solid lines. Electrodes 7a,7d, and 7e are connected together in one set to one terminal of the electrical circuit. The other set comprises 7b,7c, and 7f, all connected to another terminal of the electrical circuit. By connecting the electrodes in this manner, current flow during electrolysis will occur between the electrodes in the separate sets as illustrated by the broken lines. As much surface area as possible of the electrodes is therefore utilised in electrolysis, promoting even wear of the electrodes.

If the electrodes were connected such that eg 7a,7c,7e were connected together, and 7b,7d,7f were connected, the maximum surface area of the electrodes would not be utilised, as current would only flow between 7a and 7b, 7c and 7d, 7e and 7f.

It is possible to connect sets of electrodes together in such a way as to utilise maximum surface area for any number of electrodes in a cluster. For example consider a cluster of electrodes, 7a to 7f, with additional electrodes 8a, b and c arranged in a row adjacent to 7b, d and f respectively. To utilise maximum surface area the electrodes connected in sets would be 7c,7b,8b,7e, and 7a,8a,8c,7e,7d.

Even wear of the electrodes is very important. Uneven wear can lead to aberrations in the quantity of ions which are injected into the liquid. It becomes very difficult to maintain a constant concentration of ions in and throughout the liquid, and the purification process may become ineffective.

We have found that by providing the electrodes in clusters as illustrated, and by connecting them together in the type of manner illustrated, even wear of the electrodes is promoted. The electrodes are arranged in the cluster such that they are spaced apart evenly and disposed relative to each other and the flow of liquid, so that the surface area of each electrode is evenly swept by the liquid. The liquid thus acts to sweep any gas from the surface of the electrodes, which could otherwise result in uneven wear, and is dosed with a well controlled amount of metal ions. The current between each set of electrodes is periodically reversed. This also helps clear the electrode surface of gas.

The spacing of the electrodes in the cluster and the position of the cluster within the housing is chosen in order tc ensure even sweeping by the liquid. A process of trial and error can be used to determine the spacing and positioning ie the spacing and positioning producing the optimum results for any particular

system would be used.

More than one cluster of electrodes could be placed in a single chamber, if required.

An example of an electrical circuit which may be used to control electrolysis will now be described with reference to Figure 6.

The circuit illustrated comprises, basically, a driving section for providing current to the electrodes (not shown) connected to the terminals at the OUTPUT, and a timing circuit for providing timing signals to the driving curcuit.

The driving circuit comprises a transformer T1 arranged to be connected to the mains and having two primary windings and two secondary windings which may be connected in series or parallel depending upon the position of switch SW3. The transformer can therefore be adapted for USA mains supply (120v) or UK mains supply (240v). A variable transformer VT is provided to allow control of the output voltage of T1 (from 0-120v or 0-240v, as the case may be), so that the current to the OUTPUT can be controlled by an operator. The secondary windings of the transformer T1 are connected to the OUTPUT via solid state relays SSR1 and SSR2, diodes D1 and D2 (which act as half-wave rectifiers) and bypass resistors R1,R2 and R3. Reversible electrolytic capacitors C5 to C8 are provided with parallel resistors R8 and R9 in the circuit for smoothing of the half wave rectified signal to the OUTPUT. The output voltage and current are monitored by ammeter 100 and voltmeter 101. An arrangement comprising variable resistors VR1, VR2 and switch SW2 allows a variation in the scale reading of the ammeter 100.

The timer circuit is based on a 555 timer integrated circuit 102. Power is provided to 1/C 555 from a second Transformer T2 arranged to be connected to the mains and having windings which can be switched into series or parallel by switch SW4, in order to accomodate mains supplys of 120v or 140v. Full wave rectifier B1, voltage regulator REG1 and capacitors C1, C2, provide a d.c 6v supply to the power terminal 8 of the I/C 102. The I/C 102 is configured as a monostable which gives out a positive going pulse of 30s duration followed by a negative going pulse of 30s duration, the pulses determining which of the solid state relays SSR1 and SSR2 is enabled at any time.

In operation, one of SSR1 and SRR2 is enabled at any time, so that d.c current (halfwave rectified and smoothed a.c) is provided to the electrodes connected to the OUTPUT. After 30s the operating SSR is disabled and the other SSR is enabled, causing reversal of the d.c current to the OUTPUT. LED's (red and green) are provided which indicate the direction of current at any time. A neon lamp (N) is provided to indicate whether the switch SW1 to the mains supply is on or off.

Circuit conditions can be conveniently monitored by the ammeter 100, voltmeter 101 and adjusted as desired. The circuit of Figure 6, including ammeter 100 and voltmeter 101, may be housed in the unit 41 illustrated in Figures 1 and 2.

In the circuit diagram, resistors are generally designated R, switches SW, fuses F, capacitors C, socket and plug PLC, socket PL3 and D diodes.

A relay circuit, comprising reed relays RI 1 and RL2 are included in the timing circuit. The relays RL1, RL2 are normally closed and do not effect the circuit operation. However, a jack socket 103 is provided into which a "dose timer" (not shown) may be plugged. The dose timer is arranged to be set to count a certain

time period, during which it is desired that electrolysis will occur, and then open the relay contacts so halting operation of the circuit. This facility is useful in applications where constant operation of the apparatus is not desired.

In the embodiments illustrated in Figures 1 and 2 of the drawings the electrolytic device 40 has been shown in a position in the direct flow path of the liquid supply. The device could alternatively be placed in a bypass circuit.

For example, some cooling towers are utilised in "closed" loops, such as some air-conditioning systems. Liquid flowing into the cooling tower from the systems is cooled, collected in a reservoir at the base of the cooling tower and then put back into the system. For the reasons discussed above it is not possible to maintain the purity of the liquid in such a system by the known method of chlorination, and any aerosol given off by the system and the cooling tower can constitute a health risk. The liquid may be purified in accordance with the present invention by placing a bypass loop,for example at the base of the cooling tower reservoir, purifying the liquid in accordance with the present invention, and passing it back into the reservoir for circulation into the rest of the system.

The use of such a bypass situation is convenient for such applications, as opposed to the "full flow" technique illustrated in Figures 1 and 2. In a bypass system liquid flow rate through the electrolytic device can be carefully controlled by providing an independently controllable pump on the bypass.

Conditions for electrolysis (ie current, flow rate of liquid through the electrolyte device, etc) will depend on the particular application and what concentration of ions it is desired to input into the liquid, and the

conductivity of the liquid. Setting of the conditions will generally be by an empirical process, adjusting conditions and sampling ion concentration until the desired result is achieved. If the conductivity of the liquid is low the number of electrodes utilised may be increased.

The concentration of ions required in the liquid will depend upon the particular application to which the invention is put. The effective concentration will be that which results in the desired kill rate of microbes in the liquid. The effective concentration can be determined empirically by testing bacteria microbe counts for various concentrations of ions.

With Cu and Ag electrodes, combined concentrations of copper and silver in liquid are typically in the range of 0.01 - 1ppm copper and silver (silver concentration will be much less than copper concentration in the region of ppm for copper and in the region of ppb for silver).

Specified embodiments of the present invention have described the invention in relation to air conditioning systems and cooling towers. The invention can be used however, wherever the production of a liquid aerosol may cause concern about health. For example, in the textile industry atomised sprays are used for simultaneous humidification and cooling. Also, some liquids (not necessarily water) used in industrial processing may give rise to the production of a liquid aerosol.

The present invention has the further advantage that unlike many of the commonly known biocides, the metal ions utilised are compatible with anti-corrosion chemicals used in some liquid circulation systems.

Instead of providing a separate chamber for the electrode cluster, the cluster could be placed in an already existing space in the liquid flow system.

Composition of the electrodes of the electrolytic device is generally in the range of 3-20% Ag, 97 - 80% Cu. Other metals may be included in the electrodes eg zinc and platinum.

CLAIMS

1. Apparatus for purifying a liquid aerosol, comprising interface means for producing a liquid/gas interface, said means being arranged to have liquid input thereto, and purifying means arranged to receive the liquid input to said interface means and to dose the liquid with metal ions having biocidal properties, whereby liquid aerosol produced from the liquid/gas interface is maintained in a purified state.

2. Apparatus in accordance with claim 1, wherein said purifying means comprises a plurality of electrodes arranged in a "cluster" in the path of liquid flow, the electrodes being of a metal whose ions have biocidal properties and being arranged to be connected to an electrical circuit for electrolysis to occur such that ions from the electrodes are injected into the liquid.

3. Apparatus in accordance with claim 2, wherein the "cluster" comprises at least four electrodes, the electrodes being divided into two separate sets and the electrodes in each respective set being electrically connected together in such a way that the maximum adjacent surface areas of each single electrode are utilised in electrolysis current flow.

4. Apparatus in accordance with claim 2 or 3, wherein said electrodes are parallelepipedal in shape.

5. Apparatus in accordance with claim 2, 3 or 4 wherein there are six electrodes in a cluster.

6. A method of maintaining purity of a liquid aerosol produced from a liquid/gas interface, comprising the step of injecting metal ions into the liquid prior to the liquid reaching the liquid/gas interface, said metal ions having biocidal properties.

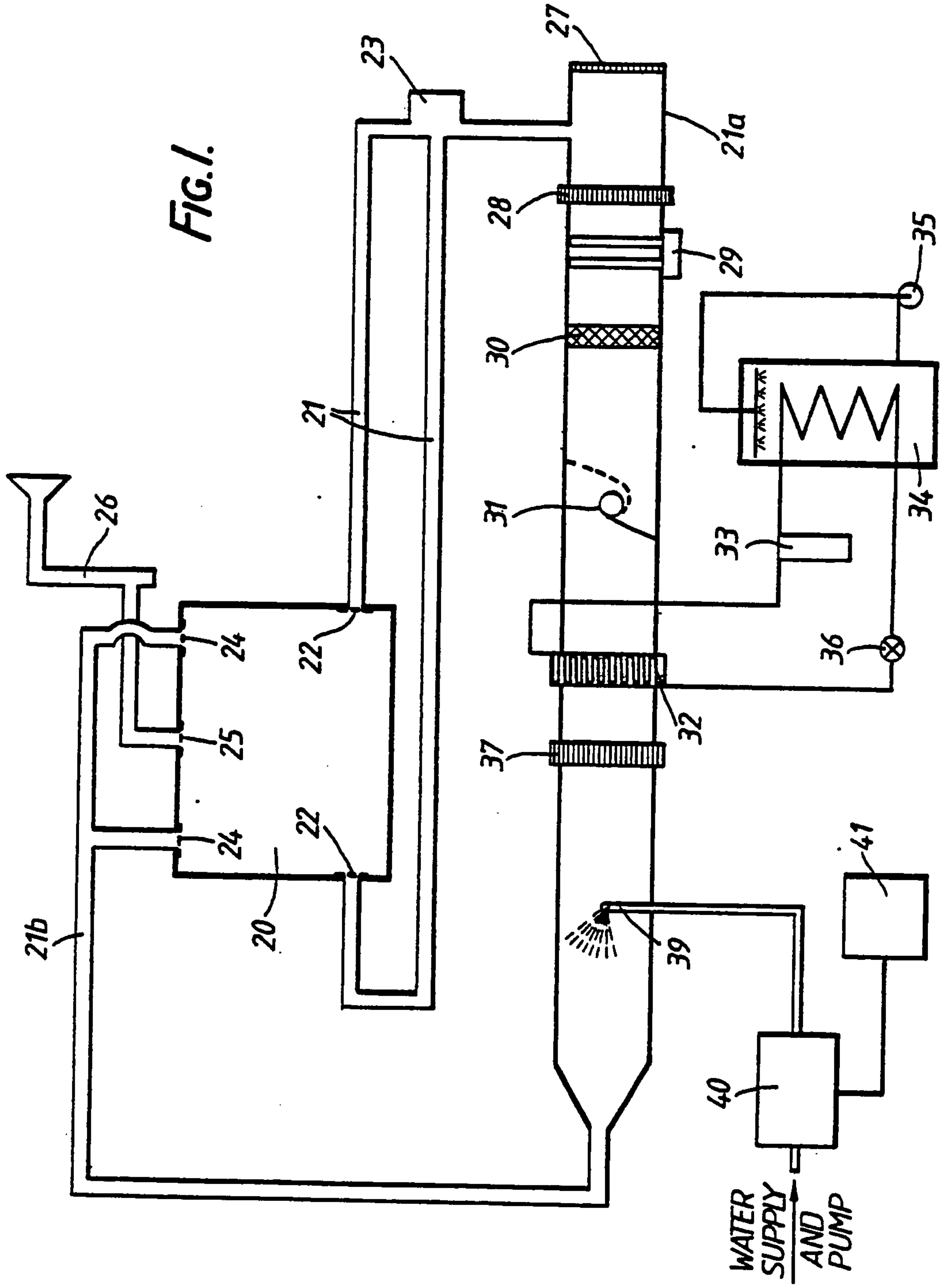
7. A method in accordance with claim 6, wherein the metal ions are injected into the liquid by a process of electrolysis between electrodes placed in the liquid path, the electrodes being of a metal whose ions have biocidal properties, and comprising the further step of periodically reversing the current between the electrodes to promote even wear thereof and to keep them clean.

8. Electrolytic apparatus for injecting metal ions having biocidal properties into a liquid, the apparatus comprising an electrode chamber having an inlet and an outlet for flow of liquid through the chamber, the chamber housing a plurality of electrodes in a "cluster" formation.

9. Apparatus in accordance with claim 8 wherein the "cluster" is made up of a number of electrodes which are divided into two separate sets, the electrodes in each respective set being electrically connected together in such a way that maximum adjacent surface areas of each single electrode are utilised in electrolysis current flow.

10. Apparatus in accordance with claim 8 or 9, wherein there are six electrodes in a cluster.

FIG. 1.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WATER SUPPLY AND PUMP

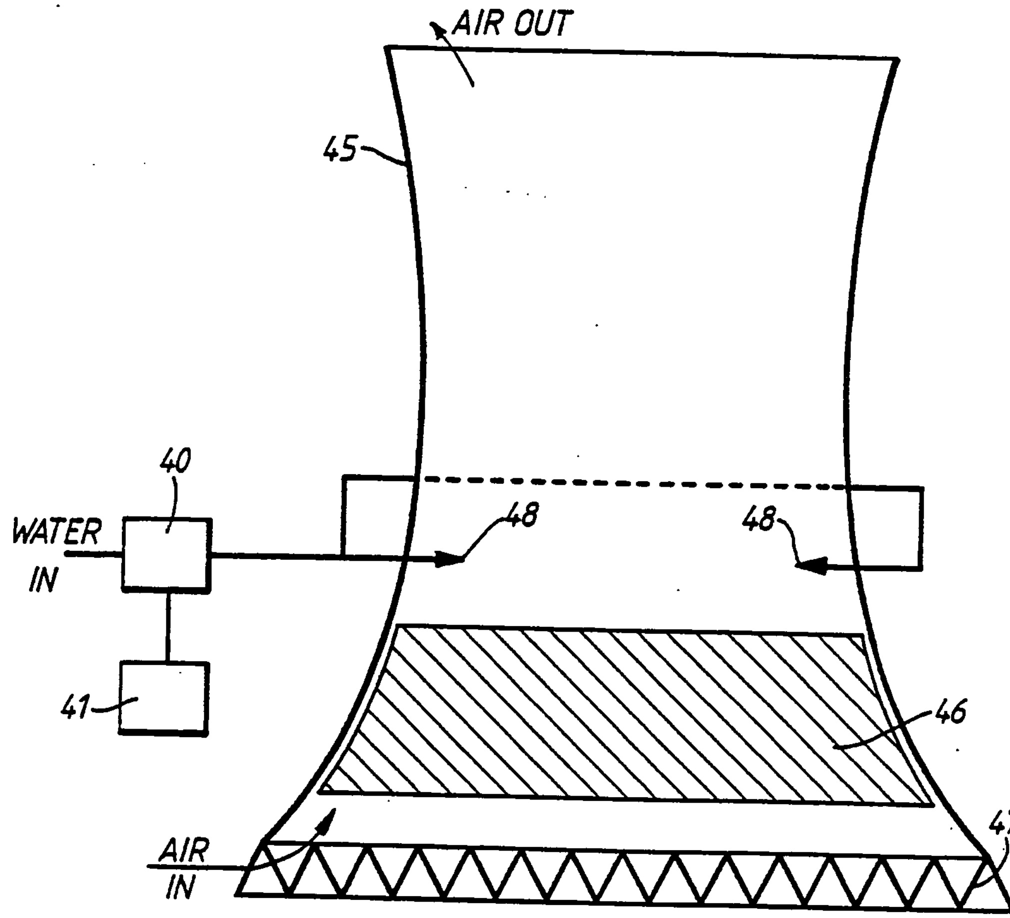

FIG. 2.

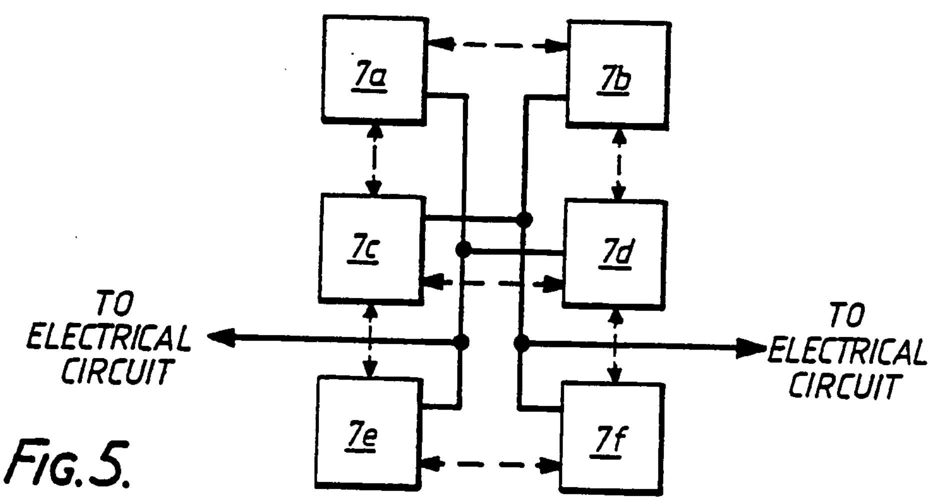

FIG. 5.

SUBSTITUTE SHEET

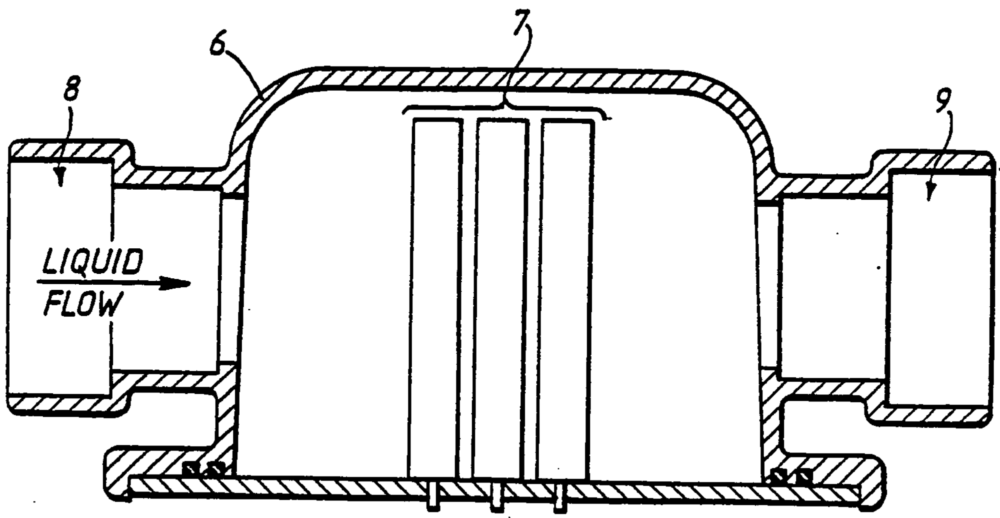

FIG.3.

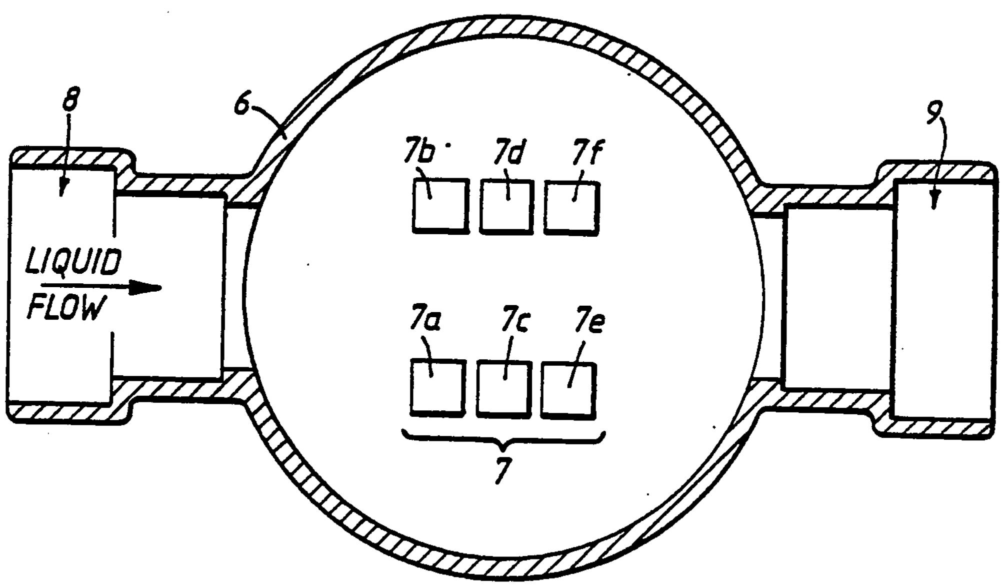

FIG.4.

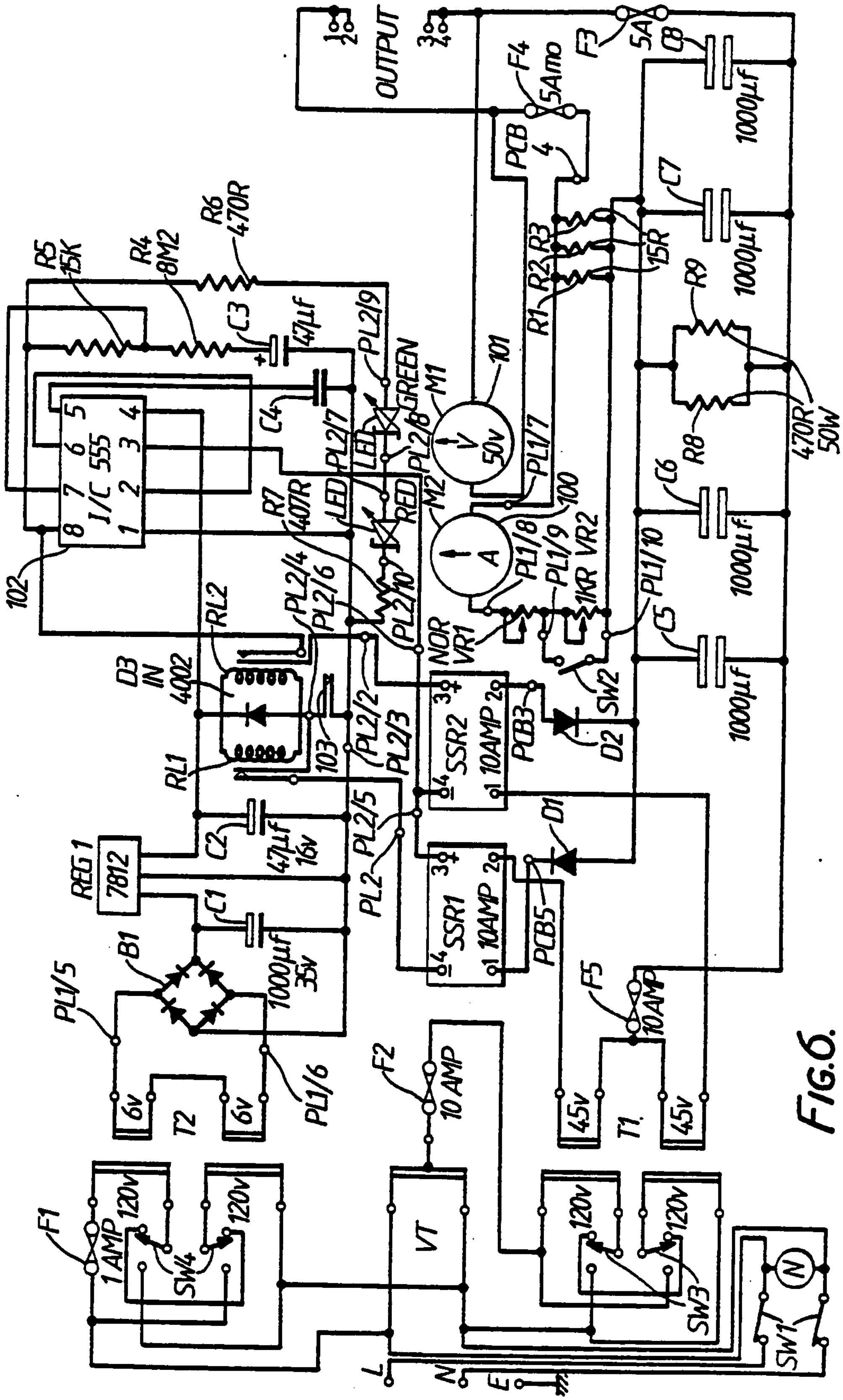

FIG.6.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00355

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: C 02 F 1/46; // F 24 F 3/14; F 24 F 6/00; F 28 F 25/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	C 02 F F 24 F F 28 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
P,X	WO, A, 87/02027 (SAFETY FIRST LTD) 9 April 1987 see abstract; page 1, lines 1-35; page 2, lines 33-37; page 3, line 17 - page 4, line 4; page 5, lines 1-25; page 11, line 19 - page 12, line 15; page 13, lines 2-7,15-23; page 16, line 14 - page 17, line 9; page 19, lines 11-16; figures 1-7 --	1,2,6-8
X	US, A, 4525253 (HAYES) 25 June 1985 see column 1, lines 10-23; column 2, lines 36-59; column 3, lines 20-39; column 3, line 61 - column 4, line 47; figure 2 --	1,2,6-8
X	US, A, 2657178 (ROBINSON) 27 October 1953 see the whole document --	1,6
X	DE, A, 1517512 (CHEMISCHE FABRIK BUDENHEIM) 18 December 1969 see page 1, lines 3-22; page 4, lines 14-21; page 10, lines 10-23; page 13,	1,6

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* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14th August 1987	16 SEP 1987
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. VAN MOL

Form PCT/ISA/210 (second sheet) (January 1985)

International Application No. PCT/GB 87/00355

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
	claims 1,6,7	
	--	
A	US, A, 3936364 (MIDDLE) 3 February 1976 see column 2, lines 15-28, 48-55; column 3, line 53 - column 4, line 65; figures 2,3	1-3,6-9
	--	
A	US, A, 3654119 (WHITE) 4 April 1972 see column 1, lines 13-17, 32-56; column 2, lines 5-17, 42-72; column 3, lines 1-11; figure 1	1-3,6-9
	--	
A	WO, A, 85/00034 (TARN PURE LTD) 3 January 1985 see abstract; page 7, claims 1,4,6; figure 2 cited in the application	1,2,6-8
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A	US, A, 3518174 (INOUE) 30 June 1970 see column 4, lines 22-36; figure 2	2,3,5,9, 10
	--	
A	US, A, 3575839 (MELNIKOV) 20 April 1971 see column 2, lines 49-57; figures 1,2	4

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 87/00355 (SA 17520)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 28/08/87

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A- 8702027	09/04/87	GB-A-	2182029	07/05/87
		EP-A-	0226284	24/06/87
		AU-A-	6401786	24/04/87
US-A- 4525253	25/06/85	None		
US-A- 2657178		None		
DE-A- 1517512	18/12/69	None		
US-A- 3936364	03/02/76	None		
US-A- 3654119	04/04/72	FR-A-	2112286	16/06/72
		DE-A-	2150670	27/04/72
		AU-A-	3449371	19/04/73
		NL-A-	7113980	14/04/72
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		US-A-	4680114	14/07/87
US-A- 3518174	30/06/70	None		
US-A- 3575839	20/04/71	None		

For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82